

REMARKS

Claims 49, 50, 55-74, 77, and 78 are pending in this application. By this Amendment, claims 49, 73, 74, 77, and 78 are amended, and claims 51 and 52 are canceled. Support for the amendments to the claims may be found, for example, in the specification at page 31, lines 10-18; page 32, line 13 - page 33, line 10; and page 48, lines 9-21; and in the original claims. No new matter is added.

In view of the foregoing amendments and following remarks, reconsideration and allowance are respectfully requested.

I. Rejections Under 35 U.S.C. §102

The Office Action rejects under 35 U.S.C. §102(b): (1) claims 49-52 as being anticipated by U.S. Patent Application Publication No. 2003/0116082 to Sakurada et al. ("Sakurada"); and (2) claims 49, 50 and 55-64 as being anticipated by U.S. Patent Application Publication No. 2003/0000457 to Oda et al. ("Oda"). By this Amendment, the subject matter of claims 51 and 52 is incorporated into claim 49. Applicants respectfully traverse the rejection.

Claim 49 requires that (1) the Cu concentration in a component made of quartz to be used in a part in which a temperature in a furnace for single crystal growth is 1000 °C or more is 1 ppb or less, and Cu concentration in a component made of quartz to be used in a part in which a temperature in the furnace for single crystal growth is less than 1000 °C is 10 ppb or less, and the components made of quartz are other than the crucible; and (2) the silicon single crystal is grown so that a defect region in the silicon single crystal contains Nv region outside an OSF ring over an entire region in a direction of a crystal growth axis and Cu concentration in the silicon single crystal is less than 1×10^{12} atoms/cm³. The applied references do not anticipate the claimed subject matter for at least the following reasons.

The applied references fail to disclose (1) the recited Cu concentrations in the components made of quartz, wherein the components made of quartz are other than the crucible; and (2) that the Cu concentration in the silicon single crystal is less than 1×10^{12} atoms/cm³. As discussed in the previous response, Applicants newly discovered crystal defects in silicon single crystals resulting from Cu contamination. See June 24, 2010 Amendment After Final Rejection at pages 10-11. From the traditional accomplishment of higher purity of the quartz crucible whose purity directly affects the crystal quality, Applicants focused their study on HZ components (e.g., the observation window) other than the raw materials or furnace components to analyze the occurrence of the new crystal defects. Applicants discovered that the source of the new crystal defects correlates with the Cu concentration in the components made of quartz other than the crucible, even though such components are not in contact with the raw material melt. See specification at page 30, line 18 - page 33, line 10.

Furthermore, Applicants discovered another source of the new crystal defects. Specifically, Applicants discovered that the new crystal defects occur particularly in the Nv region when Cu concentration in the silicon single crystal is 1×10^{12} atoms/cm³ or more. Id. The claimed method, requiring that the silicon single crystal is grown so that Cu concentration in the silicon single crystal is less than 1×10^{12} atoms/cm³, prevents the new crystal defects from occurring in the Nv region.

Conventionally, components other than the crucible, such as the observation window, have not been thought to be a Cu contamination source for forming crystal defects. Thus, quartz glass having Cu impurities of about 100 ppb has conventionally been used as the components other than the crucible for forming silicon single crystals. See specification at page 32, line 13 - page 33, line 3; and Comparative Example 1. As discussed in the previous response, Sakurada and Oda are completely silent with respect to Cu concentration. See June

24, 2010 Amendment After Final Rejection at pages 10-12. Because the applied references do not disclose Cu concentration as the source of the new crystal defects as discussed above, the applied references use quartz glass having Cu impurities of about 100 ppb, as is used conventionally to form silicon single crystals. Thus, the applied references fail to disclose components made of quartz other than the crucible having the recited Cu concentrations, or growing a silicon single crystal so that the crystal has a Cu concentration of less than 1×10^{12} atoms/cm³.

For at least these reasons, the applied references do not anticipate claim 49 and dependent claims 50 and 55-64. Accordingly, reconsideration and withdrawal of the rejections are respectfully requested.

II. Rejection Under 35 U.S.C. §102/103

The Office Action rejects claim 74 under 35 U.S.C. §102(b) as being anticipated by or, in the alternative, under 35 U.S.C. §103(a) as having been obvious over Oda. Applicants respectfully traverse the rejection.

As discussed above, Oda fails to disclose growing the silicon single crystal so that the crystal has a Cu concentration of less than 1×10^{12} atoms/cm³ to prevent the new crystal defects (discovered by Applicants) from occurring in the Nv region.

Furthermore, to achieve the above result, a time-consuming process is required in claim 74. Specifically, claim 74 requires cleaning the in-furnace components, transferring the in-furnace components to another room where the cleaning is performed, and maintaining the cleanliness at class 1000 or more, such that the components are cleaned to have high cleanliness. In contrast, as discussed in the previous response, Oda teaches a degree of cleanliness set at class 1000 only in the uppermost floor for loading the raw material, and the degree of cleanliness in the intermediate floor (where the cleaning operation occurs) is degraded to about class 10,000 during cleaning operations. See June 24, 2010 Amendment

After Final Rejection at pages 12-14; and Oda at paragraph [0040]. Oda does not teach the importance of the cleanliness of the intermediate floor, whereas claim 74 requires maintaining high cleanliness during cleaning operations to prevent the new crystal defects from occurring in the Nv region of the silicon single crystal.

Therefore, Oda does not anticipate and would not have rendered obvious claim 74 because Oda fails to disclose (1) the source of the new crystal defects, (2) growing the silicon single crystal so that the crystal has a Cu concentration of less than 1×10^{12} atoms/cm³ to prevent the new crystal defects, and (3) maintaining high cleanliness during cleaning operations. Accordingly, reconsideration and withdrawal of the rejection are respectfully requested.

III. Rejections Under 35 U.S.C. §103

A. Oda and Holder

The Office Action rejects claims 65-73 and 78 under 35 U.S.C. §103(a) as having been obvious over Oda in view of U.S. Patent No. 6,344,083 to Holder ("Holder").

Applicants respectfully traverse the rejection.

1. Claims 65-72

Claims 65-72 depend from claim 49 and, thus, contain all of the features of claim 49. Deficiencies of Oda with respect to claim 49 are discussed above. Holder, which is applied by the Office Action for the additional features recited in claims 65-72, does not cure deficiencies of Oda with respect to claim 49.

Thus, Oda and Holder would not have rendered obvious claims 65-72.

2. Claims 73 and 78

Claims 73 and 78 recite producing a silicon single crystal where "after melting of a silicon raw material is finished, it is left for 3 hours or more on a condition that a heating

heater is heated with an electric power of 80% or more...." The applied references would not have rendered obvious the claimed subject matter for at least the following reasons.

As discussed above, Oda fails to disclose growing the silicon single crystal so that the crystal has a Cu concentration of less than 1×10^{12} atoms/cm³ to prevent the new crystal defects (discovered by Applicants) from occurring in the Nv region. Holder fails to cure deficiencies of Oda as it is completely silent with respect to Cu concentration.

In order to grow a silicon single crystal so that the crystal has a Cu concentration of less than 1×10^{12} atoms/cm³, claims 73 and 78 require that after the silicon raw material is melted, the material is left for 3 hours or more under the recited electric power and flow amount conditions to exhaust Cu out of the furnace. As discussed in the previous response, Holder does not disclose the claimed subject matter but, rather, discloses a different melting and equilibrating method. See June 24, 2010 Amendment After Final Rejection at pages 14-15.

Therefore, Oda and Holder would not have rendered obvious claims 73 and 78 because Oda and Holder fail to disclose (1) the source of the new crystal defects, (2) growing the silicon single crystal so that the crystal has a Cu concentration of less than 1×10^{12} atoms/cm³ to prevent the new crystal defects, and (3) leaving a silicon raw material for 3 hours under the recited conditions after it is melted. Accordingly, reconsideration and withdrawal of the rejection are respectfully requested.

3. Conclusion

For at least these reasons, the applied references would not have rendered obvious claims 65-73 and 78. Accordingly, reconsideration and withdrawal of the rejection are respectfully requested.

B. Oda and Tsuji

The Office Action rejects claim 77 under 35 U.S.C. §103(a) as having been obvious over Oda in view of U.S. Patent No. 6,068,699 to Tsuji et al. ("Tsuji"). Applicants respectfully traverse the rejection.

Claim 77 requires that (i) the apparatus has two or more of the following: (1) Cu concentration in a component made of quartz to be used in a part in which a temperature in a furnace for single crystal growth is 1000 °C or more that is 1 ppb or less, Cu concentration in a component made of quartz to be used in a part in which a temperature in the furnace for single crystal growth is less than 1000 °C that is 10 ppb or less, and the components made of quartz that are other than the crucible; (2) devices and components being exposed in the furnace for single crystal growth that do not contain Cu as a raw material; and (3) Cu concentration in an observation window made of quartz provided in the furnace for single crystal growth that is 10 ppb or less; and (ii) the silicon single crystal is grown so that a defect region in the silicon single crystal contains Nv region outside an OSF ring over an entire region in a direction of a crystal growth axis and Cu concentration in the silicon single crystal is less than 1×10^{12} atoms/cm³. The applied references would not have rendered obvious claim 77 for at least the following reasons.

As discussed above, Oda fails to disclose growing the silicon single crystal so that the crystal has a Cu concentration of less than 1×10^{12} atoms/cm³ to prevent the new crystal defects (discovered by Applicants) from occurring in the Nv region. Tsuji fails to cure deficiencies of Oda as it is completely silent with respect to Cu concentration.

Furthermore, as discussed above with respect to Oda, because Tsuji does not disclose Cu concentration as the source of the new crystal defects, Tsuji uses quartz glass having Cu impurities of about 100 ppb, as is used conventionally to form silicon single crystals. Thus, the applied references fail to disclose components made of quartz other than the crucible,

such as the observation window, having the recited Cu concentrations, or growing a silicon single crystal so that the crystal has a Cu concentration of less than 1×10^{12} atoms/cm³.

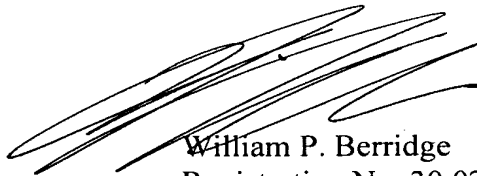
For at least these reasons, the applied references would not have rendered obvious claim 77. Accordingly, reconsideration and withdrawal of the rejection are respectfully requested.

III. Conclusion

In view of the foregoing, it is respectfully submitted that this application is in condition for allowance. Favorable reconsideration and prompt allowance of the claims are earnestly solicited.

Should the Examiner believe that anything further would be desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number set forth below.

Respectfully submitted,



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Date: December 7, 2010

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